ATHENA's Versatile Ultrasound Generator

driving and analysing various ultrasound systems with just one device

Figure 1: The big advantage of the versatile ATHENA Ultrasound Generator is that it can be applied to characterize and drive various ultrasound systems. It allows you to apply different control techniques and gives you a deep insight in the process by monitoring all relevant measurement data

Limitations of common power ultrasound generators – our motivation

Most commercial ultrasonic systems consist of a piezoelectric converter and an electrical ultrasound generator. Both are matched to a narrow frequency window and optimized for specific applications, e.g., "welding of plastics", "ultrasonic cleaning" or "ultrasonic cutting". Typical examples are welding systems working at 20 kHz with a nominal power of 2 kW or at 35 kHz and a power of 800 W. On the one hand those systems are usually well-designed for the aimed application and make use of reliable control concepts. On the other hand, these systems are not very versatile, e.g., for the development of new processes or ultrasound equipment.

⇒ How can many different ultrasound systems be characterized and driven without the need for multiple ultrasound generators?

In the development process of ultrasonic systems, the optimal driving frequency, the control strategy and the power consumption of new process are often not initially known. Often it is unclear if a process will need 20 W, 200 W, or 2 kW or which frequency is best suited (20 kHz, 40 kHz, 100 kHz or something in between or even higher?). Another typical question is, which vibration amplitudes are best suited for the application. Furthermore, different operating points (resonance, antiresonance) or driving modes (continuously, clocked) may be optimal for different processes. To find the best choice for your new application, several completely different ultrasonic actuator/resonator concepts have to be evaluated and analysed experimentally (ATHENA loves to support your project activities…). To have the possibility to experimentally investigate all the different systems and driving options at various frequencies different driving units would be required. Alternatively, a time consuming development of different test-circuits could be required (that might not be used anymore if the test does not deliver the desired results).

⇒ Especially at this stage it would be extremely convenient to have just one versatile ultrasound generator that enables you to test and drive all kinds of ultrasound systems.

Our unique solution: Plug and Play for various ultrasound systems

Formerly, a bunch of heavy und bulky laboratory equipment (impedance analyser, function generator, power amplifier, different transformers specially built for the desired application) had to be used to be able to run different ultrasonic resonators for various applications. Due to the heavy and fragile components the system was not transportable. The control software of this system had to be written by ourselves. That was a time-consuming task, but we learned how to do it from the early beginning.
With this background the consequential step for our actual work at ATHENA was to move from the laboratory equipment to one single advanced and flexible ultrasound generator using modern technologies. The possibilities of FPGA technologies combined with our deep understanding of the basics of ultrasonic resonant systems enabled us to successfully implement this really different approach and integrate it into our unique system – The ATHENA Ultrasound Generator.
The ATHENA Ultrasound Generator combines all the described equipment in one device

- ⇒ a fast and flexible digital signal generation (FPGA),
- ⇒ a broadband and powerful amplifier and
- ⇒ an adaptable transformer for a good impedance matching to the ultrasound system.

Based on this versatile hardware configuration the ATHENA Ultrasound Generator enables you to perform the following recurring tasks in the development and application of ultrasound systems with just one device:

- ⇒ Characterization of various ultrasound systems (frequency response / admittance curve)
- ⇒ Once characterized, various ultrasound systems can be driven in resonance, antiresonance, at a fixed frequency, continuously or in clocked mode and much more…
- ⇒ To get a deep insight into the process, all relevant measurements (voltage, current, power, …) can be displayed throughout the process
- ⇒ Hardware and software one-stop – because the development is completely in ATHENA's hands, custom adaptions of the generator are possible at any time

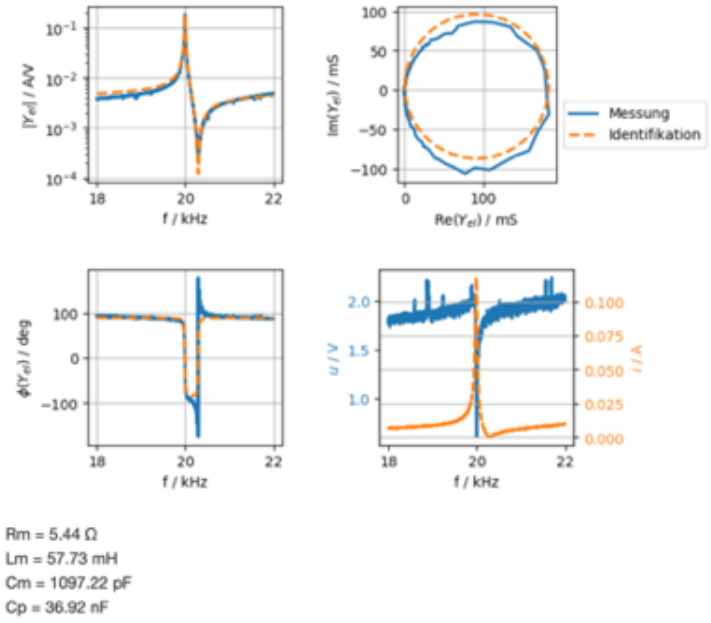

Figure 2: Frequency sweep of the admittance curve of a 20 kHz ultrasound transducer and identification of characteristic system parameters performed by the ATHENA Generator

Monitoring of process parameters

Especially in the development process and experimental investigation of your system it is very important to monitor the driving parameters of the system (power consumption, frequency, voltage, current, …) during operation. How do those parameters change over time and in reaction to varying process conditions?

⇒ Observing the main driving parameters during operation and their reaction on changing boundary conditions are a main task in the development process and give you a deep insight into your process and the performance of your ultrasound system. The gained information is the basis for a subsequent optimization of the system.

Observing measurement signals on the same time scale, on which the ultrasound system is operated (e.g., by an oscilloscope) makes it difficult to get an overview over the relevant information for your process. Even the lowest ultrasonic frequency of 20 kHz means that the ultrasound transducer vibrates 20.000 times per second and each period of this sinusoidal signal should be sampled with at least 100 points. Thus, a huge amount of data has to be handled. But usually, the process itself runs on a completely different timescale than the internal processes of signal generation and measurement. Thus, the data management should run in the background, while you focus on the important information

⇒ It would be ideal if the ultrasound generator would also handle the measurement data and display it in a manner that lets you focus on the process… without having to care about additional measurement equipment and processing of the data

The measurement data monitor implemented on the ATHENA Ultrasound Generator offers you exactly this functionality. The actual values of frequency, voltage, current, real power and other values characterizing the present state of the system are monitored during the process and can be saved for further evaluation or processing. Studying your ultrasound device under test with the support of our measurement data monitor is the ideal basis to analyse the limits of your ultrasound system and for further optimizations and development steps. It can also be used to gather important information for the subsequent development of an application specific electrical driver for the product.

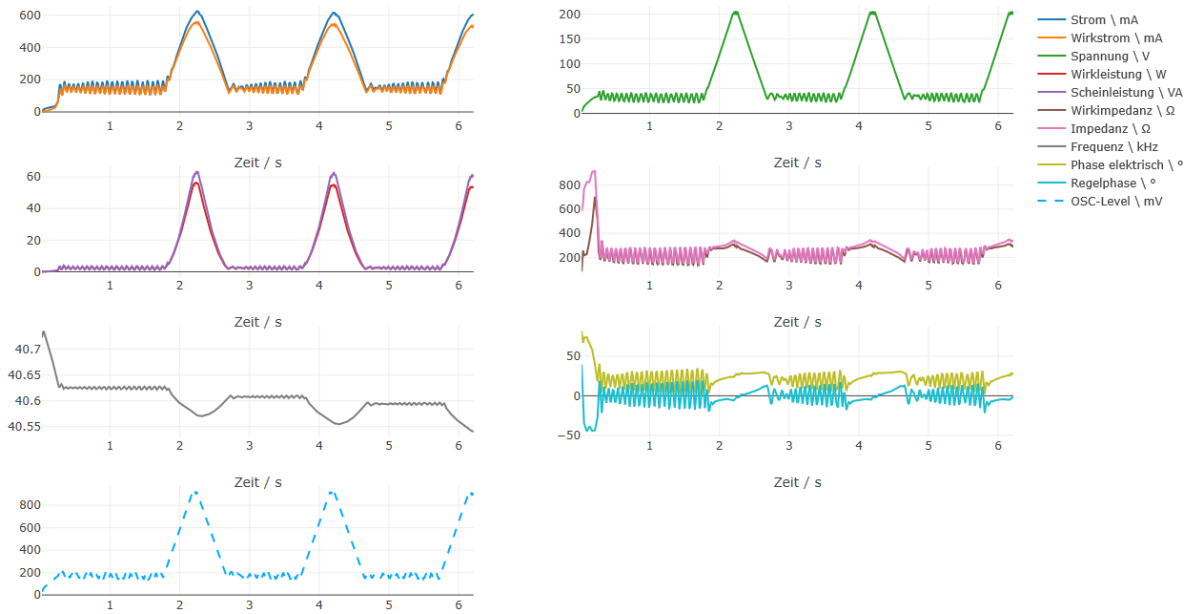

Figure 3: The data monitoring function shows the process parameters during operation. Here: periodically clocked amplitude variation of a 40 kHz transducer

The small brother – The ATHENA Resonance Control Module

If you want to test or apply your own power amplifier and/or transformer, possibly during the hardware development in your project, but you do not want to pass on the functionality and intelligence of the ATHENA Ultrasound Generator the ATHENA Resonance Control Module is the best choice for you.

Figure 4: ATHENA Resonance Control Module

Technical Specifications

- Resonance control for various ultrasound systems in the frequency range between 20 kHz and 250 kHz
- Digital frequency control and amplitude control
- Digital signal generation and measurement data acquisition (internal measurement of voltage and current)
- Power of up to 250 W (depending on the characteristics of the connected ultrasound systems)
- Maximal voltage: 450 V_{RMS} (higher voltages possible on request)
- Variable transformer for impedance matching to the connected ultrasound system
- Online-measurement-date-observation (e.g., current, voltage, real power, impedance, frequency, …)
- Control via network with various devices possible (PC, Tablet, Smart Phone)
- Network-compatible (LAN, W-LAN) and ready for industry 4.0
- Integrable in higher level controller (e.g., Labview)
- Characterization module for frequency sweeps („impedance sweep“) and automatical parameter identification for the characterization and application of various ultrasound systems

Optional Software Modules

- The functionality of the ATHENA Ultrasound Generator can be expanded by optional software modules
- Examples: antiresonance drive, clocked mode, measurement data monitoring, interactive fixed frequency operation
- Custom solutions (also subsequently) as a service possible

Your Advantages

- Due to the modular setup of the ATHENA Ultrasound Generator custom solutions are possible on the hardware side and on the software side
- Hardware and software one-stop
- Custom solutions as a service and thus not dependent on lot size (additional measurement channels, higher voltage, higher power, …)
- Developed by experts in the field of ultrasound technology and thus extensive support also concerning development and application of ultrasound equipment

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